# Carbon footprint of the global pharmaceutical industry and relative impact of its major players

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### A B S T R A C T

Despite the heightened urgency of curbing carbon emissions around the world, the healthcare sector in general, and the pharmaceutical sector in particular have received very little attention from the sustainability community in terms of their contribution to the global carbon footprint. In this paper, we conduct an analysis of the overall contributions and the historical emissions trends of the pharmaceutical sector, as well as an industry-specific comparative analysis of the major pharmaceutical companies in the world. Surprisingly, our analysis reveals that the pharmaceutical industry is significantly more emission-intensive than the automotive industry. We also use a previously published mathematical framework linking national target emissions to the target emission intensity of the pharmaceutical sector to derive the emission intensity of the pharmaceutical sector required for the US to meet its reductions commitments per the now defunct Obama-administration commitments at the 2015 Paris Agreement. We identify the excess emitters among the top-15 Pharmaceutical companies, from those that are leading the pack with their emissions improvement efforts. The results are quite instructive as we find a far greater variability amongst the Top-15 pharmaceuticals than the Top-10 automotive companies, suggesting a very disparate set of environmental practices within the industry. The paper should elicit further in-depth studies of the environmental performance of the pharmaceutical sector and help inform policy makers, business leaders and academicians on how to help curb this unwarranted level of emissions in this important and growing industry sector.

## 1. Introduction

In September 2016, the Scripps Institutions of Oceanography reported that carbon dioxide crossed the significant and symbolic threshold of 400 ppm (parts per million) for the first time in human history. Based on paleoclimatic evidence, the last time $CO_2$ levels reached 400 ppm humans didn't yet exist. Indeed, a 2009 report from the Nature Geoscience journal found evidence of levels of 365—415 ppm going back to 4.5 million years ago (Pagani et al., 2009). To bring things into perspective, the current levels of 400 ppm are about 120 ppm higher than the pre-industrial levels in the later 1800s, or more than a third higher (Pagani et al., 2009). With three quarters of the world's mega-cities, representing 80% of the world's population, located by the sea (SaveTheSea, 2017), the disastrous consequences of extreme weather events due to the

greenhouse effect are simply unfathomable. It is hence difficult to overstate the urgency of reducing greenhouse emissions on a global scale in a way that is predictable and effective. Yet, even after the historic Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC), where aggressive greenhouse gases emission mitigation targets were set (The Paris Agreement and Unit, 2016), there is still no clear strategy or game plan for how to reach those aggressive reduction targets. In fact, recent research suggests that the US is on pace to miss its 2025 target in Paris climate deal by a range of 551 to 1800 MMt-$CO_2$e (million metric tons of $CO_2$ equivalent), with resulting net changes in GHGE ranging from 0.6% above to 11.8% below the 2005 level (Greenblatt and Wei, 2016); a far cry from the promised 28% reduction even in the best case scenario. Similarly, Environment Canada recently announced that it projects to miss its 2030 GHGE target by about 30% resulting in essentially flat emissions of about 741 MMt-$CO_2$e, instead of the ambitious goal of 523 MMt-$CO_2$e promised at the landmark Paris climate summit (ECCA, 2017).

The US framework for GHGE reduction revolves around the now

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**Abbreviations**

| | |
|---|---|
| Mt-CO$_2$e | Metric tons of CO$_2$ equivalent |
| MMt-CO$_2$e | Million metric tons of CO$_2$ equivalent |
| GHGE | Greenhouse gas emissions |

*Mathematical Notations*

| | |
|---|---|
| $E(m)$ | Country-level total GHGE in year $m$. |
| $E_i(m)$ | Industry sector-level total GHGE in year $m$. |
| $E_{i,j}(m)$ | Firm-level total GHGE in year $m$. |
| $R_i(m)$ | Industry sector-level total Revenues in year $m$. |
| $R_{i,j}(m)$ | Firm-level total Revenues in year $m$. |
| $\Delta(m)$ | Country-level cumulative reductions in GHGE from year 0 to year $m$. |
| $\Delta_i(m)$ | Sector-level cumulative reductions in GHGE from year 0 to year $m$. |
| $I_i(m)$ | Sector-level Emission Intensity in year $m$. |
| $I_i^t(m)$ | Sector-level Target Emission Intensity in year $m$ to meet national goal. |
| $I_{i,j}(m)$ | Firm-level Emission Intensity in year $m$. |
| $RI_{i,j}(m)$ | Relative Emission Intensity of a firm with respect to its sector in year $m$. |

defunct Obama Administration's Clean Power Plan, which includes passed and proposed legislation, as well as potential policy or voluntary measures to support the announced reduction target. These wide-reaching measures cover electricity and building codes, fertilizer management, appliance standards, heavy-duty vehicles, oil and gas CH$_4$ leaks, manure management and landfills CH$_4$ emissions (INDC, 2015). Although the US Environmental Protection Agency (EPA) has included carbon pricing, in the form of cap-and-trade, as an option for implementation plans, it has left it up to the individual states to decide to what extent pricing will be used to achieve the Clean Power Plan goals (Lawson, 2016). On the other hand, Environment Canada has made carbon pricing the first and most important pillar of its four-pillar framework to achieve its 30% target reduction of GHGE by 2030 (ECCA, 2017). For both countries however, the unfortunate reality is that it has become exceedingly clear that neither set of policies appear to be enough to reach those self-assigned goals (Greenblatt and Wei, 2016; ECCA, 2017).

While the spotlight on emissions reduction has been mostly focused on industrial sectors, such as mining, energy and automotive industries, the carbon footprint of the healthcare industry, and more particularly the pharmaceutical sector, have received little to no attention from the peer-reviewed literature. The dearth of peer-reviewed literature on the Pharma emissions may lead one to think that it's a relatively green industry. Indeed we could only find one direct reference to the subject by Chung and Meltzer, dating to 2009, who estimated the 2007 carbon footprint of the US health care sector (Chung and Meltzer, 2009). They found that the total US Healthcare sector contributed an estimated total of 546 MMt-CO$_2$e (Million Metric tons of CO$_2$ equivalent). The largest contributors to that footprint were the hospital and prescription drug sectors (39% and 14% respectively). Also, the authors pointed out that in 2007, this level of emissions accounted for 8% of the total US GHG estimated at 7150 MMt-CO$_2$e, while the healthcare sector accounted for 16% of the US gross domestic product in that same year. The only other detailed study of the carbon footprint of the healthcare sector that we could find is one by the Sustainable Development Commission of the United Kingdom's National Health Sector (NHS, 2012). The 2014 report finds that the total carbon footprint of the NHS, Public Health and Social Care system amounts

to 32 MMt-CO$_2$e in 2012, representing 38% of the public sector emissions in England and 3.6% of England's consumption emissions (823 MMt-CO$_2$e). Pharmaceuticals accounted for 16.25% of that total footprint, representing the largest contributor, followed closely by Building energy (15%), commissioned health and care services (14.7%) and travel (13.1%). Medical instruments/equipments were the fifth largest contributor and accounted for 9% of the total sector's footprint.

In another related and recent study, Eckelman and Sherman assessed the environmental impacts of the US Health Care System and its effects on Public Health. They found that the sector accounted for a significant fraction of the national air pollution and impacts, including 12% of acid rain, 10% GHG emissions, 10% smog formation, 9% of air pollutants, 1% to the stratospheric ozone depletion and 1—2% to the carcinogenic and non-carcinogenic air toxins (Eckelman and Sherman, 2016). Larsson conducted an extensive review of the pollution impact of drug manufacturing, which in contrast to GHGE, received a lot more attention from the scholarly community (Joakim Larsson, 2014). The review pointed out that drug discharges to the environment, while not precisely documented by the pharmaceutical companies, had been found to reach some extreme levels in some cases. The author cites as an example, amongst many others, the instance where the estimated daily release of a broad-spectrum antibiotic from drug manufacturers in Patancheru, India, amounted to 44 kg; enough to treat everyone in a city of 44,000 habitants. Similar levels of discharges were also observed in other factories in China, Korea, Taiwan and Pakistan according to the review. In sum, the relatively few studies that are available concur that the pharmaceutical sector is responsible for a significant level of environmental damage in the form of GHG emissions and pollution in the form of excessive discharges.

In this paper, we undertake what we believe to be the first assessment of the global carbon footprint of the pharmaceutical sector. We follow Belkhir & Jackson (B&J) methodology and framework (Belkhir et al., 2017) by analyzing the individual performance of the fifteen largest Pharma companies relative to their industry emission intensity, where the emission intensity is defined as the total Scope 1 + 2 emissions in metric tonnes of CO$_2$e divided by the firm's total revenues in millions of US dollars, hence carrying the unit of Mt-CO$_2$e/\$M (USD). This method allows us to readily pinpoint the excess emitters (i.e. those whose emission intensity is larger than the industry's average), and the high performers and benchmark, i.e. those who have a lower intensity emission than their sector's, and the company with the lowest emission intensity respectively. Next, using the formalism detailed by B&J, we calculate the target emissions intensity for the pharmaceutical sector from 2015 through 2025, that would need to be achieved in order to meet the 28% target reduction promised (and later withdrawn by president Trump) by the US at the Paris Summit (INDC, 2015), taking into account the forecasted market growth for the sector. We then discuss the policy and managerial implications for the pharmaceutical sector as a whole, as well as for specific major pharmaceutical companies, in light of the gap between their current emissions level and the one they need to achieve year-over-year in order to be compliant and help achieve the set or desired target.

## 2. Material and methods

### 2.1. Conceptual development

Per the detailed methodology explained by Belkhir and Jackson, we assume that the total GHGE of any given country is well known and measured in metric tonnes of CO$_2$ equivalent (Mt-CO$_2$e). We restrict our emissions to Scope 1 (direct emissions) and Scope 2

(indirect emissions) only. Scope 3 emissions are excluded to avoid double-counting. Since we only consider Scope 1 and 2 emissions from electricity use, and consider the GHGE by end-use sector, we effectively attribute the GHGE from electricity production to the sectors that use that electricity. We hence exclude the electricity generation by utilities companies since this would cause double-counting as well.

In their paper, B&J provide the justifications to the use, as a key metric, of the emission intensity metric defined as the ratio of Mt-$CO_2e$ to the operating revenues generated by either the entity or the total sector in millions of dollars ($M). This emission intensity ratio defined relative to revenues has been widely used in sustainability and emissions reporting frameworks such as GRI (Global Reporting Initiative, 2600; CDP, 2016), although both the GRI 4.0 and the CDP guidelines allow organizations to use their own organization-specific denominator, which can be profit, EBITDA, units of productions, etc. We refer the reader to their article for a review of their full argument.

### 2.2. Data collection and analysis

For our data, we used primarily the ET Carbon Dataset from ET Index Research, which produces a public Carbon Ranking of the world's largest listed companies and access to 2000 companies, analyzed directly by ET Index Research (E. Index, 2017), as well as additional data from the Carbon Disclosure Project CDP (CDP, 2016) and from Google Finance (Google FInance, 2018). In some specific cases, we've had to consult directly the annual reports of the companies in question. Among other data, the ET Index dataset provides the Scope 1 and 2 of the pharmaceutical sector as well the emissions intensity in Mt-$CO_2e$/$M (USD) for the years 2010, 2012, 2014, and 2015 only. We restricted our analysis to the years of 2012 and 2015 data only. In some cases, where the revenues were missing from either the ET Index or CDP data, we consulted the companies' annual reports to fill the gaps.

### 2.3. Data availability

The data that supports the findings of this study are available from ET Index Research but restrictions apply to the availability of these data, which were used under license for the current study, and hence are not publicly available.

### 3. Theoretical framework

We refer the reader to the seminal work by Belkhir & Jackson (referred herein sometimes as "B&J"), for the detailed mathematical foundation of their framework for measurement and reporting of emissions at the national, industry sector, and entity levels. We content ourselves in this article to summarize the key results that we need to perform our analysis.

Let $E(n)$ represent the carbon budget in the $n^{th}$ year and $\Delta(n)$ be the reduction in emissions that is necessary over $n$ years to reach that goal. Also, let $\eta$, represent the portion of $E(n)$ produced by the integrality of all the commercial sectors combined. Then for all of the $j$ entities within each of the $i$ sectors, which we shall assume here to remain constant over the horizon of time under consideration, we obtain

$$\sum_i E_i(n) = \eta E(n), \quad \sum_j E_{i,j}(n) = E_i(n). \tag{1}$$

Also, assuming the sum total of the target reductions by the commercial sector is proportional to its contribution, we also have

$$\sum_i \Delta_i(n) = \eta\Delta(n), \tag{2}$$

it follows after some derivations that the *projected* target emissions intensity of the sector $i$ at any given year $0 < n < N$ is given by the following expression:

$$I_i^t(n) = \frac{E_i(0)}{R_i(0)}\cdot\frac{(1-\delta)^{n/N}}{(1+d_i)^n} = I_i(0)\exp[n\ln(1-\delta)/N - n\ln(1+d_i)], \tag{3}$$

where $\delta = \Delta_i(N)/E_i(0)$, the relative target reduction by year $N$, and $d_i$ is the average expected growth of the sector $i$ with the time horizon under consideration, i.e. between 0 and $N$ years.

Any firm belonging to that sector must achieve both an emission intensity and a total absolute emissions level, given by the following equations:

$$I_{i,j}(n) \leq \begin{cases} I_i^t(n), & \text{on a projected basis} \\ \dfrac{E_i(0) - \Delta_i^t(n)}{R_i(0)\cdot\prod_{m=1}^{n}(1+d_i(m))} & \text{on an actual basis} \end{cases} \tag{4}$$

$$E_{i,j}(n) \leq r_{i,j}(0)\cdot\left(E_i(0) - \Delta_i^t(n)\right)\cdot\prod_{m=1}^{n}\left(\frac{1+d_{i,j}(m)}{1+d_i(m)}\right), \tag{5}$$

where $r_{i,j}(0)$ is the company's $i$ market share on year 0, and $r_{i,j}(n)$ is defined as:

$$r_{i,j}(n) = \frac{R_{i,j}(n)}{R_i(n)} = r_{i,j}(0)\cdot\prod_{m=1}^{n}\left(\frac{1+d_{i,j}(m)}{1+d_i(m)}\right), \tag{6}$$

and where $R_i(0)$ is the revenue of firm $i$ on year zero, and $\Delta_i^t(n)$ is the target reduction in absolute emissions for firm $i$ on year $n$, starting from year zero, which will be 2015 in our case.

Eqs. (4) and (5) are the main results of the B&J framework. The input values therein are all known, and the equations are the actionable results of this framework that an entity can use to aim for its own as well its nation's targets. In Eq. (4), the *projected basis* version of the equation is used to set a numerical target for the firm based on the projected target emission intensity for the sector, given by Eq. (3). Once the actual growth of the sector $i$ is known for the year $n$, then the *actual basis* version is to be used to compare with the actual emission intensity achieved by the firm $j$ for that same year.

As a graphical representation of the framework, we reproduce in Fig. 1, courtesy of Dr. Belkhir, a graphical representation of the cascading of the emissions reduction target from the national down to the commercial entity level for every year $n$ as described in the B&J theoretical framework presented above. The national reduction targets can be broken down into sectors, and entities within sectors. The emissions intensity metric can be used to compare entities within a sector, allowing them to reach their targets. An entity with a relative intensity of greater than 1 is poorly performing while an entity with an $RI_{i,j} \leq 1$ has reached or is outperforming the emissions targets. For the sake of simplicity of illustration, we have assumed here that the growth rates for the sector and the entity are constant year over year.
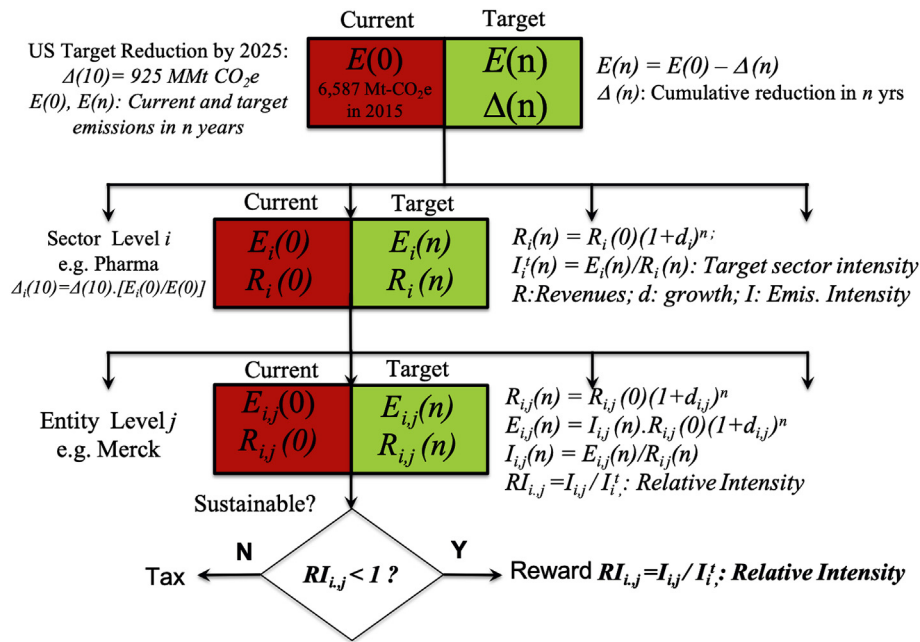
**Fig. 1.** Flow diagram showing the cascading year-over-year of the national-level target reduction down to the commercial entity level, and the sustainability condition to test whether a given entity has met its fair share of reductions relative to the target reductions.

## 4. Results

### 4.1. Overview

We examined the Pharma industry over a four-year period from 2012 to 2015, which was the period of time for which reliable data was available for all of the firms of interest. Of the more than two hundred companies representing the pharmaceutical market, there were only twenty five (SDU-NHS, 2017) major Pharma companies that reported their scope 1 and scope 2 emissions in 2015, and of those only fifteen (CDP, 2016) (referred herein as Group of 15) reported their emissions consistently from 2012 through 2015 (CDP, 2016; E. Index, 2017). The aggregate revenues achieved by the 25 companies in 2015 amounted to USD 737,850 M, or about 70% of the total sector revenues in 2015 (Statista and Global Pharmace, 2018).

One immediate and striking result is that the pharmaceutical sector is far from being a green sector. In fact, the sector's emission intensity in 2015 was 48.55 Mt-$CO_2$e/\$M, which is about 55% higher than that of the Automotive sector of 31.4 Mt-$CO_2$e/\$M for that same year (Jackson and Belkhir, 2018). In absolute value, we estimated the aggregate global emissions of the Pharma sector to amount to about 52 MMt-$CO_2$e in 2015 compared to about 46.4 MMt-$CO_2$e emitted by the global automotive sector in that same year (Statista, 2018a) (where "MMt" indicates Million of Metric tons).

Fig. 2 shows the change in emissions for the 15 Pharma companies that consistently reported their emissions in the 4-year period of our study. At first blush, Pfizer, Abbott and Merck seem to be leading the pack with 3-year reductions of 41.4%, 40.6% and 32.6% respectively. On the other hand, companies such as Johnson & Johnson and Amgen show only modest 3-year reductions of about 8% each.

This picture however changes dramatically when plotting the normalized relative emission intensity ratios of these same companies in 2015, as shown in Fig. 3. There we see that Abbott that had the second highest reduction in emission from 202 to 2015 is in fact the third worst performer with a normalized intensity of 0.36, i.e.

having an emission intensity that is 36% *higher* than its industry sector. We also find that P&G which showed a 3-year emission reduction of 11.7% in Fig. 2 is in fact the second worst performer with an normalized relative intensity of 1.06 or 106% higher than its sector's average. Even the worst performer of all, Eli Lilly, with 120% higher emission intensity than its sector, seemed to show some modest reductions of about 5% from 2012 to 2015. As for the best performers, we discover that Roche is by far the best performer in 2015 with a normalized relative intensity of −0.60, or 60% below it industry sector average, followed closely by J&J and AMGEN with relative intensities of −0.55 and −0.52 respectively. All three companies showed unremarkable, even if still significant, reductions in emissions between 2012 and 2015, which is now understandable since they're already performing at better than half the emission intensity of their sector.

To explain these results, it is worth noting that on January 1, 2013, Abbott completed the sale and separation of AbbVie Inc., for USD 5726 M, representing about 30% of its 2012 annual sales and saw its total scope 1 + 2 emissions dropping from 1,656,000 to 1,008,000 Mt-$CO_2$e from 2012 to 2013, or 39.1% accounting for most of its 40.6% reduction from 2012 to 2015. Also, on February 2015 Abbott completed the sale of its developed markets branded generics pharmaceuticals business to Mylan Inc (Mylan) for about USD 1752 M, as well as the sale of its animal health business to Zoetis Inc. These divestitures represent more than 7% of its 2014 annual sales, and hence account for more than the balance of reductions in emissions. As for Pfizer, the company with the largest percent reduction in emissions from 2012 to 2015 of 41.4%, also incurred a decline of revenues of 11% in that same period, accounting for a significant portion of its change in emissions.

On the other hand the best performers in emission intensity relative to their sectors, which are Roche, J&J and Amgen all showed very significant increases in revenues amounting to 27.2%, 25.7% and 7.8% respectively between 2012 and 2015, while still managing to reduce their emissions by 18.7%, 8.3% and 8% respectively during that same period. It's also remarkable that the leader of the pack, namely Roche, achieved both the highest increase in revenues as
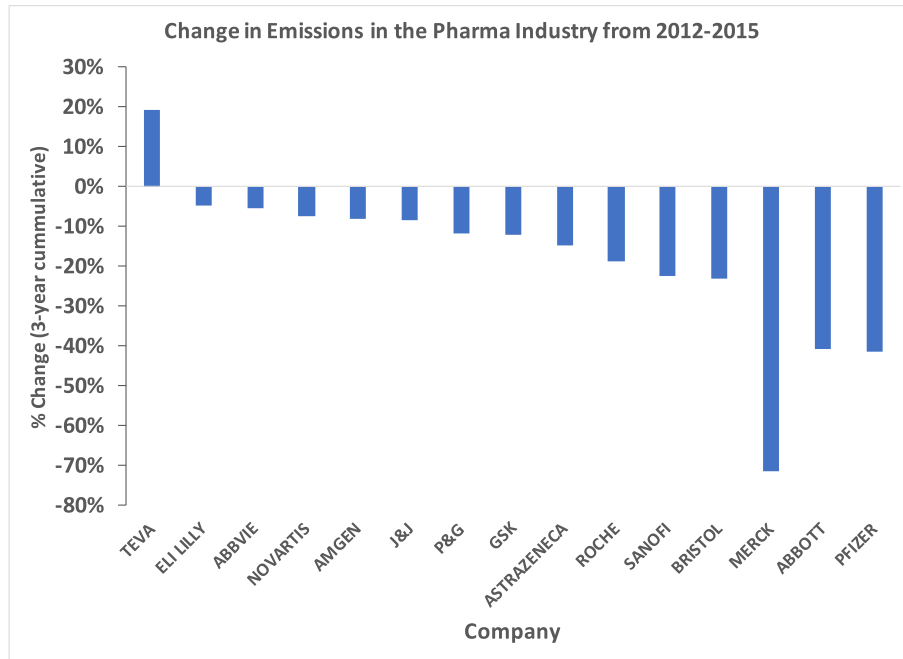
**Fig. 2.** Change in $CO_2$ emissions by the Group of 15 from 2012 to 2015. Source: ET Index Research.
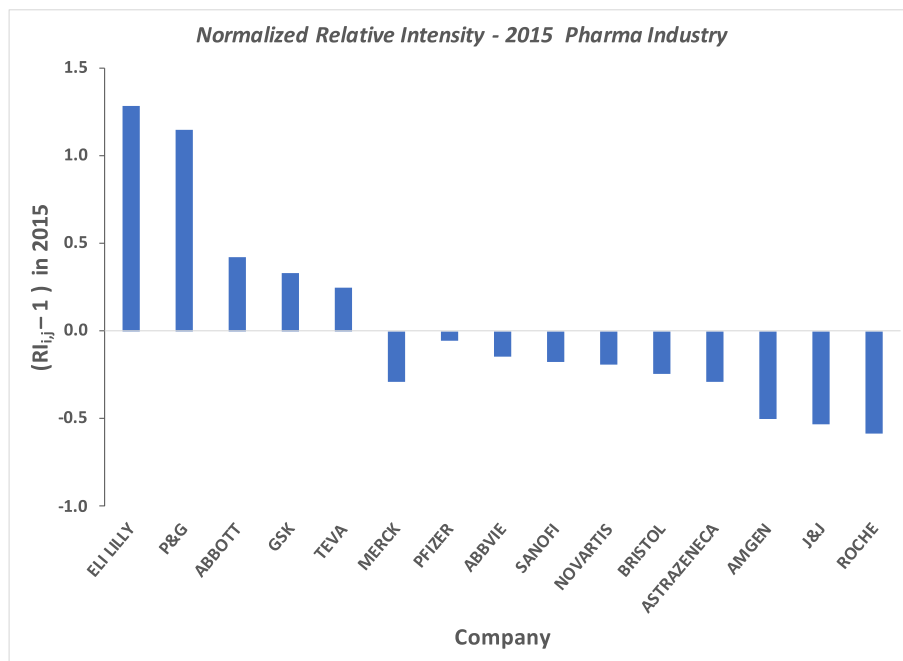


**Fig. 3.** Normalized relative emission intensities for the top 15 Pharma companies. Below zero are companies that are better than their sector and above zero are worse.

well as the highest reduction in emissions, suggesting once more, albeit on an anecdotal basis, that financial and environmental performances are far from being exclusive.

### 4.2. Emission intensity

Next, we need to calculate the emission intensity at the sector level that is required to be achieved in order to comply with the US-based emission reductions targets of 28% by 2025 (relative to 2005 levels) committed by the Obama administration in the Paris

Agreement (INDC, 2015). Taking into account the 11.5% reductions achieved from 2005 to 2015, the annual reductions in emissions required amount to $\delta = 1.9\%$ per year from 2015 and onward. Also, we estimated the historical average annual growth of the pharmaceutical sector by performing a regression fit for the aggregate sector revenues from 2001 to 2016 (Statista, 2018b), and which yielded an average annual growth rate of 7.14%, with an $R^2 = 94.7\%$. We then use Equation (The Paris Agreement and Unit, 2016) to derive the emission intensity target curve that the pharmaceutical sector must meet or exceed in order to stay on track with the US

reduction target. The curve is shown in Fig. 4.

The curve shows that by 2025, the emissions intensity of the whole pharmaceutical sector should drop from its current 48.6 Mt-$CO_2$e/\$M to 20.1 Mt-$CO_2$e/\$M, or a relative reduction of 58.6% from current levels. Should the sector growth be greater than 7.14% per year, then the reductions required would be even greater.

In Fig. 5, we show the 2015 emissions intensity of the 15 pharmaceutical companies plotted against the sector's target emissions intensity in 2015, 2020 and 2025 required for the sector to meet the 2025 US GHGE reductions target, as calculated in Fig. 4. This allows us to immediately identify how well each company fares not only against the current sector level, but also against future sector levels. We observe that only 2 out of the 15 are far exceeding their 2015 sector emissions intensity, while 8 companies exceed the 2020 required intensity level, and only 3 companies, namely Roche, J&J and Amgen already meet and even exceed the 2025 reduction target of 20.1Mt-$CO_2$e/\$M with emission intensities of 14, 15.9 and 17 Mt-$CO_2$e/\$M, respectively. A remarkable result of this approach is that it enables the easy identification of the sector leader(s) that can serve as benchmark for the rest of the sector players. Also, it provides evidence that the dramatic cuts in emissions that those leaders have been able to achieve did not undermine their financial performance. Indeed the overall sector grew by 10.7% cumulative growth between 2012 and 2015, while the Group of 15 companies had actually a negative cumulative growth of −9.23% during that same period. In contrast, the group leaders Roche, P&J and Amgen achieved a 3-year cumulative growth of 7.8%, 7.8% and 25.7% respectively. What's even more remarkable is that with the exception of Abbvie that achieved a 3-year cumulative growth of 26.9%, all the other 11 companies of the Group of 15 had negative cumulative revenue growth over the 3-year period.

It is also instructive to look at the change over time in the emissions intensities of the Group of 15 companies analyzed above as a reflection of their efforts to improve their environmental efficiency. Fig. 6 shows the emissions intensity for the Group of 15 for 2012 and 2015 side by side. We observe that only 7 of the 15 have significantly reduced their emission intensities in that 3-year span.

Those are Merck, Pfizer, Abbvie, Sanofi, Amgen, J&J and Roche. On the other hand, another 7 companies actually increased significantly their emission intensity, namely Eli Lilly, P&G, Abbott, GSK, Teva, Novartis and Astrazeneca. Finally, only Bristol maintained its emission intensity at the same level.

## 4.3. Absolute emissions

Finally, to complete our analysis, we look at the absolute emissions of each of the companies of the Group of 15 in 2015. For the purpose of this analysis, and in the absence of sufficient and reliable data for the companies outside the Group of 15, we will treat the Group of 15 companies as a sub-sector of its own, and require that the group as a whole achieve a net reductions in emissions of 17.5% from 2015 to 2015, where the 17.5% is the balance of reductions in emissions from 2015 onward that the Obama administration committed to achieve by 2025. We use Eq. (4) to determine their maximum allowable emissions year over year, from 2015 to 2025. Although Eq. (4) as written takes as input the actual yearly growth in the firm's market share and the overall sector, we will assume, for projections purposes, that each firm will maintain its 2015 market share, and hence achieve an average annual growth that is equal to that of the overall sector, namely 7.1%. This further simplifies Eq. (4), and reduces it to:

$$E_{i,j}(n) \leq r_{i,j}(0) \cdot \left( E_i(0) - \Delta_i^t(n) \right), \qquad (7)$$

Applying this equation to the pharmaceutical sector, we can easily now calculate the maximum allowable emissions for each company between 2015 and 2025 as shown in Figs. 7 and 8, where we split the 15 graphs among two figures for the sake of convenience for the reader. We observe that the Group of 15 is split into three (The Paris Agreement and Unit, 2016) categories of firms; (i) ones that need to reduce their emissions drastically in order to meet their fair share, and those include Eli Lilly (62%), P&G (60%), Abbott (39%), Glaxosmithkline (35%), Teva (31%) and Merck (20%); (ii) companies that are already performing within a fairly small
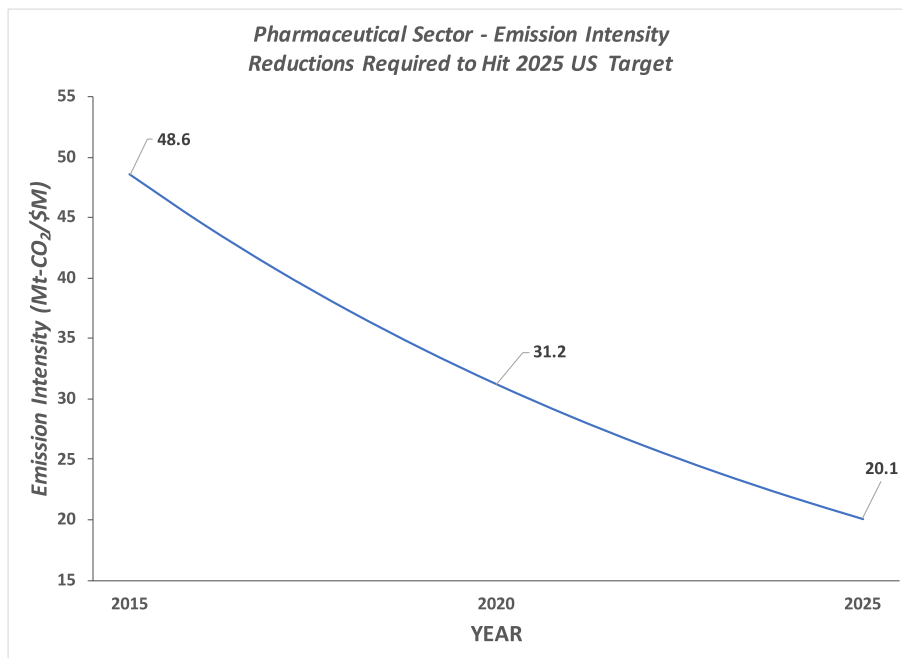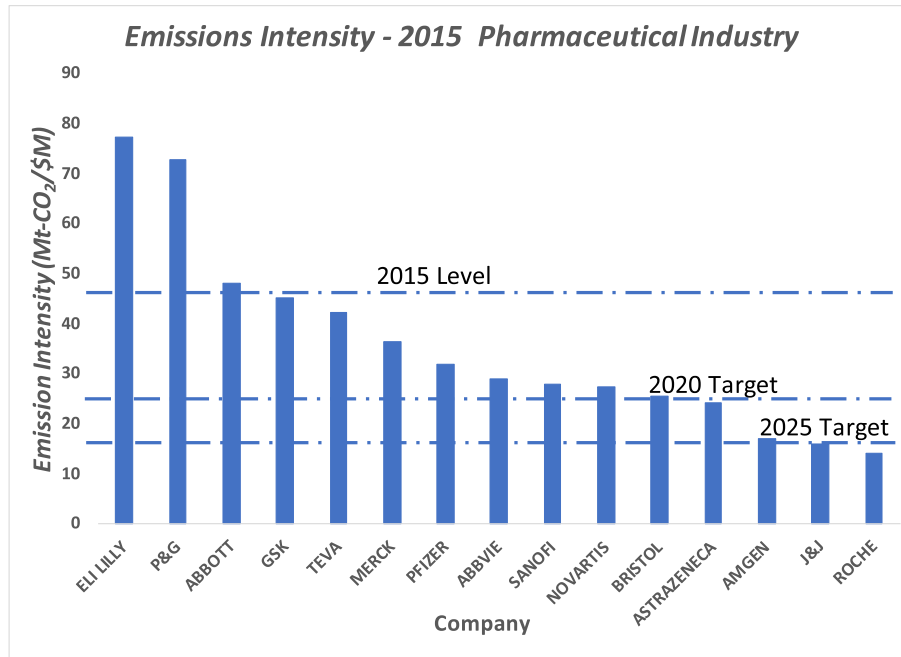


**Fig. 4.** Projection of the emission intensity of the pharmaceutical sector that is required to meet the US GHGE reduction target of 28% reduction in 2025 compared to 2005 levels.

**Fig. 5.** Emission intensities for the Group of 15 companies in 2015, shown with the emission intensity of the pharmaceutical sector in 2015, along with the projected levels in 2020 and 2025 that need to be achieved by the sector as a whole in order to achieve the US target reductions of 25% by 2025 compared to 2005 levels. (Source: ET Index Research.)
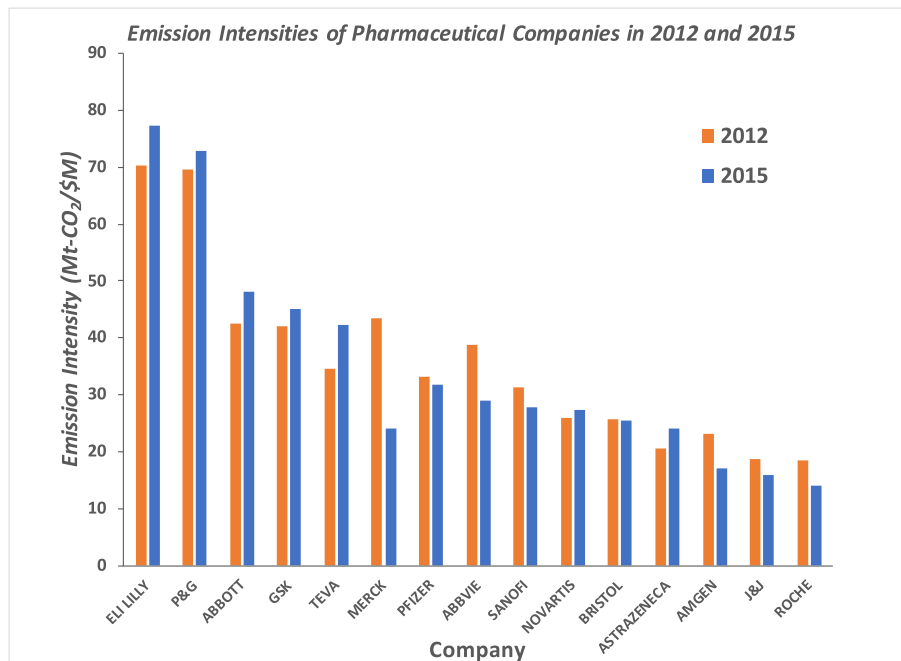


**Fig. 6.** Historical emissions intensities for the Group of 15 companies for the years of 2012, and 2015. (Source: ET Index Research.)

range of where they need to be, such as Merck, Pfizer, Abbvie, Sanofi and Novartis, and finally (iii) companies that are already or almost meeting their future 2025 emissions target and hence have an increasing allowable level between the present to 2025. Those include Roche, J&J, Agen, Astrazeneca and Bristol, where the first three are already performing below the 2025 target and the last two are between the 2020 and 2025 targets. It's important to note that the "allowable level" is not the "target level", but rather the maximum emissions level that a company can emit without

exceeding its fair share of emissions. This is the level of emissions that policy makers could use to trigger potential penalties and additional carbon taxes.

## 5. Discussion

Let us now discuss some of the limitations of our study. Although the Group of 15 represents about 60% of the total pharmaceutical sector, the lack of sufficient and reliable emissions and
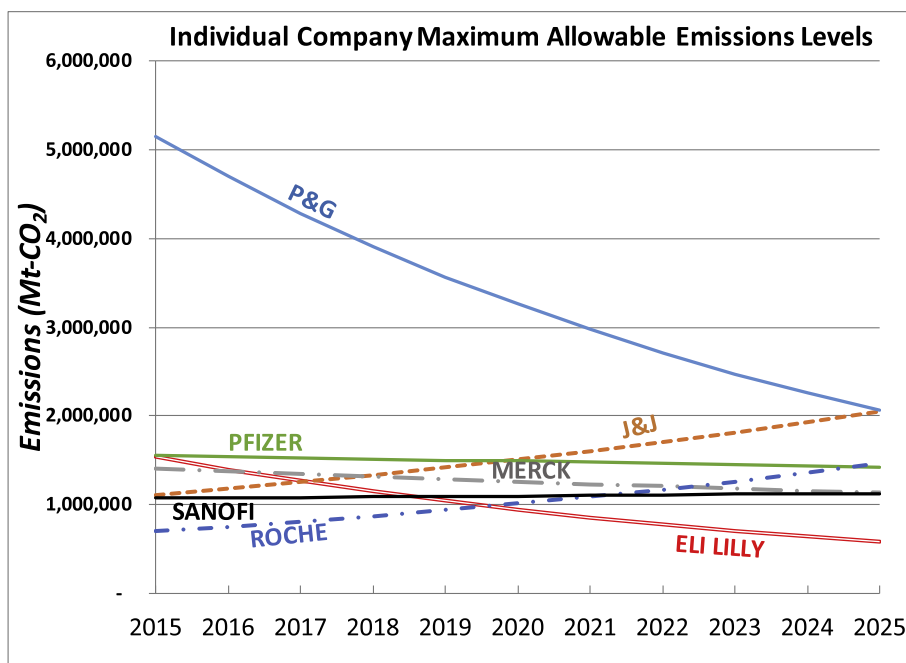
**Fig. 7.** Maximum allowable emissions in Mt-CO₂e for Eli Lilly, J&J, Merck, P&G, Pfizer, Roche and Sanofi to meet the US GHGE reduction target of 28% reduction in 2025 compared to 2005 levels.
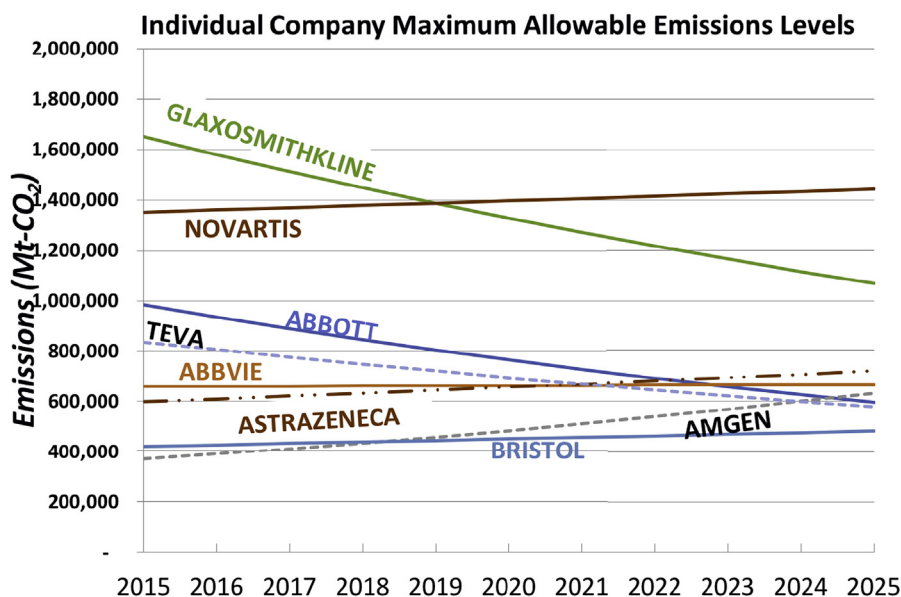


**Fig. 8.** Maximum allowable emissions in Mt-CO₂e for Abbott, Abbvie, Amgen, Astrazeneca, Bristol, Glaxosmithkline, Novartis, and Teva to meet the US GHGE reduction target of 28% reduction in 2025 compared to 2005 levels.

revenue data from the remaining companies makes it difficult to set precise emissions targets on the Group of 15. Indeed, while the total pharmaceutical sector had an average emission intensity of 48.6 Mt-CO₂e/$M, the Group of 15 emission intensity was only of 35.35 Mt-CO₂e/$M. Technically speaking, the B&J model prescribes setting the emission intensity and emissions reduction targets to each firm based on its overall sector. In our case, we chose to apply it instead to the Group of 15 separately due to the high level of diversification among some of the other pharmaceutical companies. As a notable example, Bayer which is classified as a major pharmaceutical company reported in 2015 scope 1 + 2 emissions of

9.7 MMt-CO₂e and revenues of $51,430 Millions, yielding an emission intensity of 189 Mt-CO₂e/$M. This intensity level is about 4.2 times greater than the overall pharmaceutical sector, and about 5.4 times greater than the Group of 15 level. In other words, while Bayer's revenues account for about 9.3% of the Group of 15 aggregate revenues, it emits about 50% of the group's aggregate emissions. In trying to explain this very large deviation from its industry sector, we found that Bayer's revenues derive from three larges divisions, including pharmaceutical products, medical equipments and agricultural commodities. However, while Bayer reports it financial revenues separately for each division, it lumps together

the emissions from all the divisions without distinction, which makes it impossible to figure out the emission intensities for each division. To make matters worse, Bayer reports and tracks its emission intensity in terms of tons of $CO_2e$ per ton of manufactured sales volume (Bayer, 2015, 2018), regardless of whether the manufactured goods are pharmaceutical products, medical devices or agricultural products. In other words, a ton of fertilizer and a ton of aspirin, are equally accounted for with respect to the level of emissions they generate. On that basis, we have excluded Bayer from our Group of 15 analysis. This case raises the bigger conundrum of how to analyze and assess the GHGE performance of diversified companies with respect to their particular sector. Indeed the B&J model assumes comparability within the sector in order to set the firm's individual reduction target. In theory, the model itself can be easily extended to the firm's division level, but this is only practical if both revenues and emissions are reported separately at the division level by each company of that sector. This level of granularity is unfortunately not available from any company that we analyzed so far, nor is it even encouraged by any of the current reporting frameworks such GRI (Global Reporting Initiative, 2600). It would however be extremely helpful to achieve a reasonable level of transparency and accountability.

What is really needed, in lieu of the current voluntary sustainability reporting frameworks, is a mandatory framework, as first pointed out by Belkhir and Jackson, that requires companies to issue "sustainability statements" that follow a standardized, comparable and contextual format, that is reminiscent of financial statements. Only then, can we assess the true performance of any company with respect to any of the relevant sustainability metrics, be it emissions or otherwise.

Another limitation of our study is the fact that we have relied on the US emission reduction target set by the now-defunct Obama Clean Power Plan. This however was for illustrative purposes only, and the same analysis can be done using the reduction targets of any country's or group of countries, e.g. the EU. While the model, as it stands, lends itself to country-specific target setting, it is probably not easily feasible for companies to comply with several country-specific emissions reductions, and hence have to deal with different emission targets. One possible way out would be for companies to strive to achieve the most aggressive emissions target of any country in which they have a significant presence. Another approach would be to comply with the country-specific emission reductions targets that are assessed based on their revenues in those specific countries.

Furthermore, we have shown at the end of our analysis how the model can be used by the individual firms to project out their maximum allowable emissions based on their country's reduction targets, their sector economic growth, as well as their own growth. It may come as somewhat counter-intuitive that those allowable emissions may actually increase for certain companies, such as Roche, J&J, and Amgen, when the overall sector emissions have to decrease year over year. We have explained in our results section how the allowable emissions are not the same as target emissions, but rather the maximum emissions a company can afford without exceeding its fair share of emissions, defined as a relative emission intensity of 1 for that particular year. Hence, a company, such as Roche or J&J, that has a relative emission intensity much smaller than 1 would be allowed to have a higher level of emissions before facing any potentially punitive carbon pricing or taxation measures. That is not to say however that companies who perform in that regime should be encouraged or even expected to increase their emissions.

Finally, the above paragraph suggests a potentially interesting twist on carbon tax policy. Currently, most versions of carbon taxes impose a flat tax per ton of $CO_2e$ emissions. The B&J model and this study support instead a different model where a differential carbon tax would be applied based on whether a company is below or above its required sector's emission intensity, whereby companies with a lower emission intensity than their sector's would pay a lower carbon tax rate than the baseline tax, and those with a higher emission intensity would pay a higher carbon tax rate. While this twist on carbon tax policies was already suggested by Belkhir and Jackson, this study further confirms the utility of their proposal.

Perhaps the most interesting implication of our study is the need to put a greater research focus on the environmental footprint of the Pharma industry and encourage more extensive studies on their environmental practices as a whole that go beyond their emissions.

## 6. Conclusion

In conclusion, we have used the B&J model, which is a science-based, goal-driven, equitable, comparable and actionable framework for assessing and reporting emissions of the pharmaceutical industry. Unexpectedly, we found that the Pharma industry, on average, is a higher intensity emitter than the automotive industry which was analyzed by Jackson and Belkhir using the same model and the same methodology (Jackson and Belkhir, 2018). Also, we have found a much greater variability among the Pharma industry than the automotive industry. Even after excluding clear outliers such as Bayer, and restricting our analysis to the Group of 15, we found a difference of 5.5 times between highest intensity emitter (i.e. Eli Lilly at 77.3 Mt-$CO_2e$/$M) and the lowest intensity emitter (i.e. Roche at 14 Mt-$CO_2e$/$M) in 2015. By comparison, the variability in the automotive industry was only of 3.46 times between the highest intensity emitter (GM at 49.5 Mt-$CO_2e$/$M) and the lowest intensity emitter (BMW at 14.3 Mt-$CO_2e$/$M) in that same year. Another way to state this is that P&G emits almost 5 times more than J&J, while generating almost the same level of revenues and selling similar lines of products.

We believe that this study along with a more systematic application of the B&J model to other industry sectors can be effectively used to objectively and systematically assess the GHGE performance of specific sectors and the individual firms therein. This in turn, could be used to enable the formulation and deployment of more equitable and effective policies, such as carbon pricing, that will be deployed in a targeted and performance-based manner rather than across the board and indiscriminatingly. Standardized reporting in such a way that every entity's emissions intensity uses the entities' revenue as their denominator, as well as division-level emissions reporting, would be required to facilitate comparability and accountability. Furthermore, the ability to identify a benchmark that is already meeting or even exceeding its fair share of the GHGE reductions, such as Roche and P&G in this case, could be used as a powerful incentive for the other industry players to learn and transfer their best practices in ways that are reminiscent of the Quality Movement in the 70's and 80's, when the US companies were seriously challenged by the Japanese companies with better and lower cost products.

Finally, this study is the first one to our knowledge that lifts the veil on an industry that has received a dearth of attention about its environmental practices, and where some of the largest firms have managed, through systematic greenwashing, to project an unrealistic level of environmental performance. In fact, we have uncovered an industry that is significantly worse than the automotive industry. In attempting to compare our findings with the few other relevant studies on the broad environmental practices of the Pharma industry, such as (Chung and Meltzer, 2009), (Eckelman and Sherman, 2016) and (Joakim Larsson, 2014), we could not find any direct study of the carbon footprint of the pharmaceutical

industry. The few that looked at this industry included Veleva et al. which only looked at the types and levels of GRI indicators voluntarily reported by six pharmaceutical companies, but did not actually evaluate their environmental performance, and concluded that this level of reporting was representative of the state of the art of the industry (Veleva et al., 2003). Another related study by Adams but specific to a major yet unidentified British Pharmaceutical company (nicknamed Alpha) did an extensive study of Alpha's ethical, social and environmental impacts (Adams, 2004). The author's conclusion was "the company's lack of full disclosure" regarding any of those impacts. The author adds that "the Alpha [sustainability] reports portray the company as one that is doing well, trying hard and seeking to do better. In contrast, the data on Alpha's impacts and efforts to curtail them from external sources is different". While not directly comparable to our study, the above papers nonetheless reinforce our results that show that overall the environmental performance of the pharmaceutical sector in general, and their GHG emissions in particular, are much worse than generally portrayed by the industry's greenwashing tactics and their sustainability reports.

To conclude, the surprising dearth of research on the topic of our paper is especially disconcerting, as the healthcare sector is bound to only increase in importance as the developed world's population continues to age steadily over the foreseeable future. We hope that our work will elicit other studies of the environmental performance and practices of the pharmaceutical industry to further our understanding of this important sector of our economy and inform policy makers, academics and business leaders alike on how to help curb the environmental excesses of some of the major players of this industry.

## Additional information

## Acknowledgements

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